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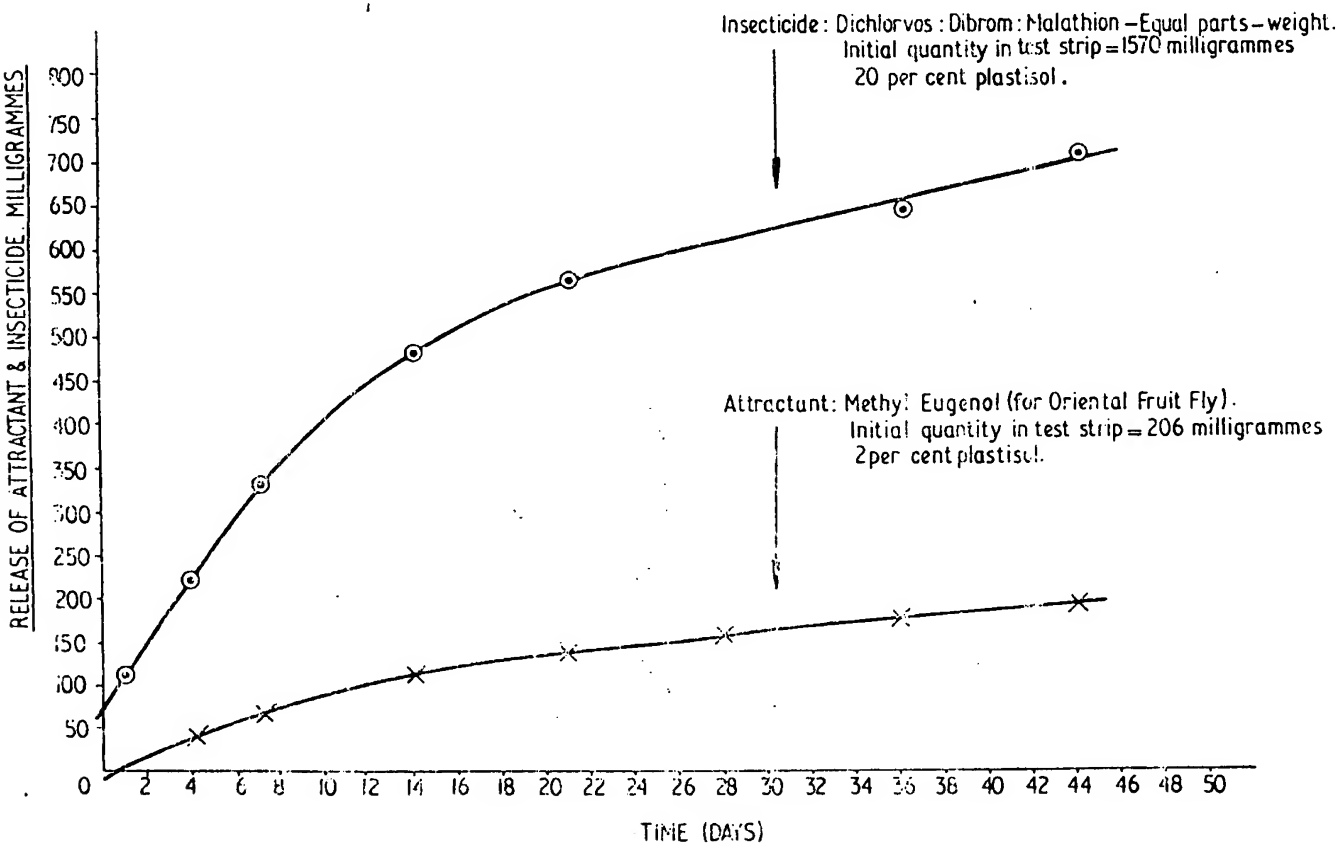
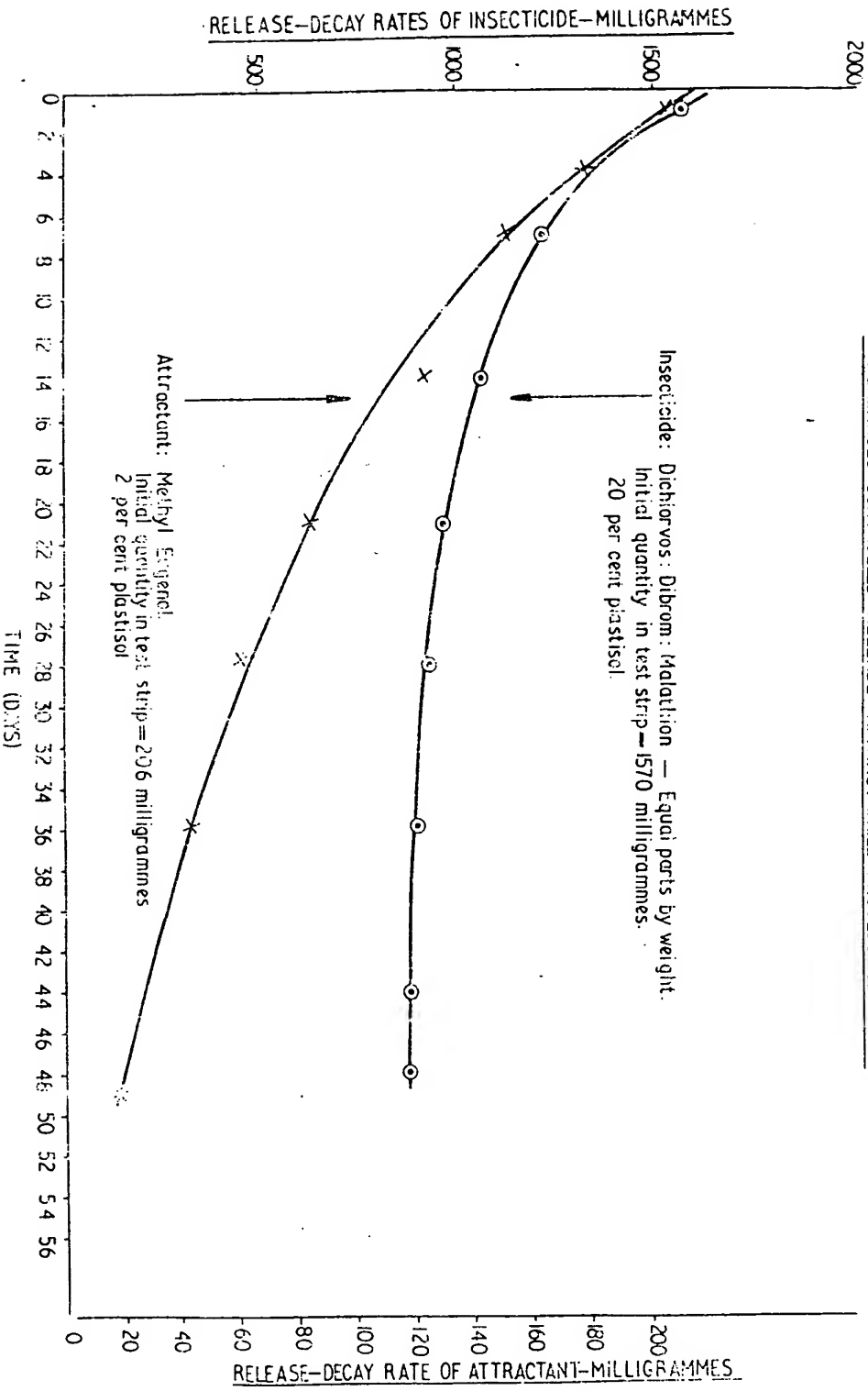
(54) **Insect control systems**

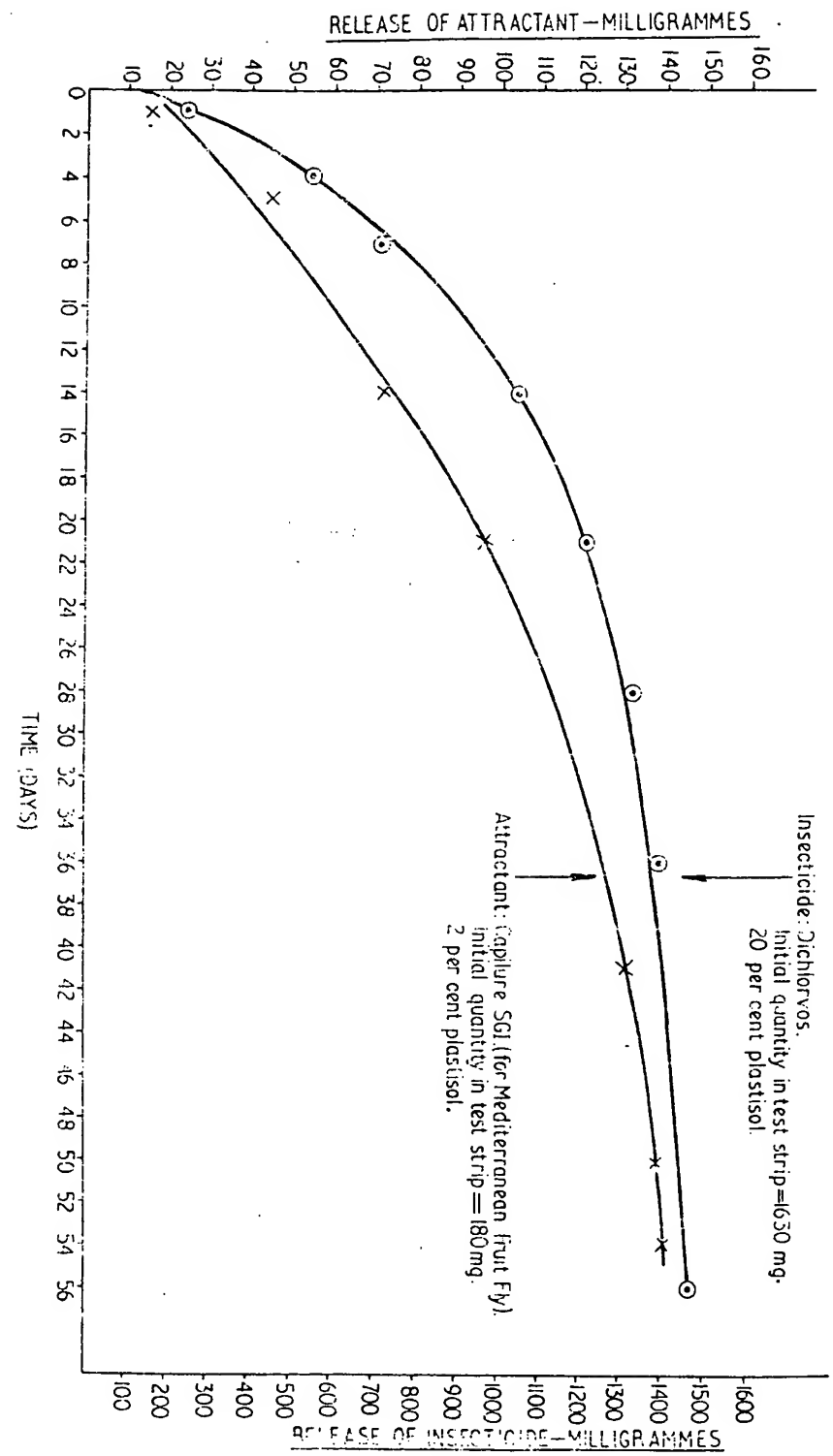
(57) This invention relates to insect control systems comprising insect attractants and insecticides in carrier compositions formulated to ensure comparable effective lives for the two compositions. The carriers may be P.V.C., P.V.A. or acetate chloride copolymers, polyolefins, chlorinated polyethylene, urea and melamine formaldehyde resins, polyesters, polyurethanes, polyureas, gelatins, straw, cane, lignocellulose, silica, aluminosilicates or clays, or the active substances may be microencapsulated. The compositions may be in the form of tapes or strings, or particles disposed on a polymeric sheet. The system may be used in conjunction with an insect trap.

GRAPH I – EXAMPLE I. LIFE AND RELEASE OF ATTRACTANT AND INSECTICIDE IN BALANCED CONTROLLED RELEASE "ATTRACT & KILL" PROCEDURES





GRAPH 1A—EXAMPLE 1A RELEASE-DECAY RATES OF ATTRACTANT AND INSECTICIDE IN BALANCED CONTROLLED RELEASE 'ATTRACT & KILL' PROCEDURES



GRAPH 2 – EXAMPLE II. LIFE AND RELEASE OF ATTRACTANT AND INSECTICIDE IN BALANCED CONTROLLED RELEASE 'ATTRACT & KILL' PROCEDURES

SPECIFICATION

Insect control systems

This invention relates to insect control systems. More particularly, the invention relates to an insect control system which optimises and generally minimises the use of insecticides and can, in preferred forms, be species specific with regard to the insects affected by the system.

The term "insecticide" as used in this specification is intended to include orthodox chemical insecticides and appropriate insect virus, bacterial or hormone compositions able to affect the specific insect species under attack. The insecticide can be of the contact type, or one which is effective in the form of its vapour.

Insecticides have been used for many years to combat various insect species which cause damage to crops. Insecticides are frequently dangerous and persistent chemicals and, hitherto, they have usually been applied to crops by dusting or spraying, either from the ground or from the air, the insecticide being directed to the space occupied by the crop to be protected and its surroundings. Hence, larger quantities of insecticides are used than would be used if the insecticide could be applied directly to, and only to, the target insect.

In addition to the large quanitities of insecticides used, such application techniques are indiscriminate in that all insect species present and the crop itself are contaminated with significant quantities of insecticide. Insecticides so broadcast will affect both useful insects, such as pollinators and also insect predators, which attack the harmful or target insect and can, in many circumstances, be counter-productive.

Since the insecticide will directly contact the crop which is to be protected, if the crop is a food crop, it is normally not safe to apply the insecticide for many days immediately prior to harvesting the crop.

Finally, many insecticides are persistent and applying large quantities of such insecticides to areas of land can create a long-term pollution problem, the consequences of which are not fully understood.

It is known that in many insect species behaviour of the insect is influenced by certain specific volatile substances and mixures of substances. Such chemical substances may, for example, be emitted by the female insect and serve to indicate her location to the male, which travels to the source of the substance. In other cases, volatile substances from appropriate host plants will direct the female to lay her eggs on such plants. In addition, it has been found that certain volatile substances are attractive to particular insect species, although the exact significance of the attraction is not fully understood. In many of these cases the volatile substance is species specific—that is to say, attracts one species of insect. These volatile substances are sometimes known as pheromones, lures or attractants and can attract insects over significant distances. All these substances are hereinafter referred to as insect attractants.

It has now been found that insecticides and insect attractants can be incorporated into compositions from which they can be discharged at a predetermined rate and the present invention provides an insecticidal system which avoids the need to scatter large quantities of insecticide over growing crops and can be used to attract specific insects to an appropriate insecticide, hence reducing the risk of damaging non-harmful insects.

Accordingly, the present invention provides an insect control system comprising an assembly of at least one insecticidal carrier composition and one insect attractant carrier composition, said compositions being formulated to provide effective lives for the compositions of substantially the same period.

In a preferred form of the invention, the effective life of the insecticide is longer than that of the insect attractant so that under no circumstances will the attractant exist in the absence of the insecticide.

The insecticide and insect attractant incorporated into carrier compositions can be mounted in an insect trap or juxtaposed compositions can be prepared: one containing the insecticide and the other the attractant, for example as intertwined strings or tapes.

The carrier composition can conveniently be a polymer plastics material, which will release the attractant and insecticide over a period of some weeks, or alternatively, if a fairly fast release rate is required, a cellulosic material, such as compressed paperboard, may be employed. Conveniently, the carrier composition is biodegradable, although if the insecticidal system is to be employed in association with an insect trap or container, then it is frequently convenient to use a polymeric material which can be mounted in an appropriate container or trap. In addition a silica gel adsorbate may be used as the carrier for either or both of the compositions.

Conveniently, the carrier composition comprises a polymeric sheet material incorporating the insecticide and carrying, on at least one surface, a secondary carrier composition

containing the insect attractant, the secondary composition being in the form of discreet particles.

The secondary carrier composition may be applied to the surface of the polymeric sheet material or may be embedded in the polymeric material.

In any case, the formulation of the carrier compositions must be such that the insecticide and attractant are released in accordance with the time requirements of the present invention.

Preferably, the discreet particles, formed from the secondary carrier composition and the insect attractant, are small, for example, in the range of diameters up to half the length of the insect under attack.

In another form of the invention one of the compositions is in micro-encapsulated form and carried on the surface of the other composition.

When a vapour phase effective insecticide is to be employed, the system is preferably placed in a partially closed trap or container, to ensure adequate vapour concentration in close proximity to the insect attractant.

Suitable insect attractants, or lures, are set out in Table I below.

TABLE I

Attractant (Lure)	Chief Insect Pests Against which Lure is Used
1. Cue-lure* 4-(p-acetoxy phenyl)butan-2-one	Dacus cucurbitae (Coquillett) (Melon Fruit Fly) Dacus tryoni (Froggatt) (Queensland Fruit Fly) Dacus dorsalis (Hendel) (Oriental Fruit Fly)
2. Methyl eugenol 4,5 dimethoxy propenyl benzene	Ceratitis capitata (Wiedemann) (Mediterranean Fruit Fly)
3. Trimedlure Isobutyl ester of 2 methyl (4/5) chloro cyclohexane carboxylic acid	Trichoplusiani (Hubner) (Cabbage Looper)
4. (Z)-7-dodecan-1-yl acetate	Laspeyresia pomonella (Linnaeus) (Codling Moth)
5. (E,E)-8-10 dodecadien-1-ol	Adoxophyes orana (Summer Fruit Tortrix Moth)
6. (Z)-9 tetradecenyl acetate (E)-9 tetradecenyl acetate (Z)-11 tetradecenyl acetate (E)-11 tetradecenyl acetate	Choristoneura fumiferana (Clemens) (Spruce Budworm) Choristoneura occidentalis (Freeman) (Western Spruce Budworm)
7. (E)-11-tetradecenal	Spodoptera exempta (Walk) (Army Worm)
8. Z-9-tetradecenyl acetate 20 parts (Z)-9, (E)-12 tetradecadien-1-yl acetate 1 part	Spodoptera littoralis (Boisd) (Egyptian Cotton Leaf Worm)
9. (Z,E)-9,11-tetradecandien-1-yl acetate	Heliothis virescens (Fabricius) (Tobacco Budworm)
10. (Z)-9-tetradecenal (Z)-11-hexadecenal	Ceratitis capitata (Wiedemann) (Mediterranean Fruit Fly)
11. Capilure*	Spodoptera frugiperda (J.E. Smith) (Fall Armyworm Moth)
12. Z-9-tetradecen-1-ol acetate (Z,E)-9,12-tetradecandien-1-ol acetate	Prodenia eridania (Cramer) (Southern Armyworm Moth)
13. (Z)-7, hexadecen-1-yl acetate	Pectinophora gossypiella (Saunders) (Pink Bollworm)
14. (Z)-11 hexadecenal	Heliothis zea (Boddie) (Bollworm, Corn Ear Worm, Tomato Fruit Worm)
15. (Z)-11-hexadecenyl acetate	Sesamia inferens (Walk) (Purple Stem Borer Moth)
16. Z-11-hexadecenal-5-parts (Z)-13-octadecenal 1 part	Chilo suppressalis (Walk) (Striped Rice Borer)
17. Disparlure cis 7, 8 epoxy-2-methyl-octadecane	Porthetria diapar (Lo) (Gypsy Moth)

(*Trade Mark of Food Industries Limited Bromborough, England.)

It will be appreciated that other known attractants or lures can be used in the system provided by this invention.

Orthodox chemical insecticides suitable for use in this invention include the following:

Dichlorvos	2,2,dichlorvinyl-dimethyl phosphate
Naled, Dibrom	1,2-dibromo-2,-2, dichloro ethyl dimethyl phosphate
Malathion	0,0-dimethyl S-diethyl-mercapto succinate phosphorodithioate
Synthetic pyrethroids	e.g. Resmethrin
Carbamates	e.g. (3-methyl-1-phenyl-5-pyrazolyl dimethyl carbamates), Carbaryl (1-naphthyl methyl carbamate)
Fenthion	00 dimethyl 0-4 methylthio-m-tolyl phosphorothioate
Acephate	O–S dimethyl acetyl phosphoramidothioate
Chloropyrifos	0-0 diethyl 0-3-5-6 trichloro-2-pyridyl phosphorothioate
Phosmet	0-0 dimethyl-S-phthalimidomethyl phosphorodithioate
Trichlorphon	Dimethyl (2-2-2) trichloro-1-ethyl phosphonate
Diazinon	0-0-diethyl 0-2 isopropyl-6-methyl pyrimidin-4-yl phosphorothioate
Phenthoate	S-α-ethyoxycarbonyl benzyl-00-dimethyl phosphorodthioate
Propoxur	2-isopropoxyphenyl methylcarbamate
Dimethoate	00 dimethyl S-methylcarbamoyl-methyl-phosphorodithioate

Insecticides as hereinbefore defined of the insect virus type suitable for use in this invention are described in:

(1) Falcon 1976. Annual Review of Entomology, page 305, "Problems Associated with use of Arthropid Virus in Pest Control".

(2) Smith, K. 1976. "Virus Insect Relations", Longman (Chapter 19).

(3) David, W.A.L. 1975. Annual Review of Entomology. "Status of Virus Pathogens for Insects and Mites", page 97;

and these references are hereby incorporated into this specification.

An example of a bacterial composition useful as the insecticide, according to this invention, is Bacillus Thuringiensis.

It will be appreciated that other insecticides can be used additional to those listed above by their Trade Names, chemical names or genus names.

As mentioned earlier, the attractant and insecticide can be incorporated into cellulosic materials or polymer materials such as polyvinyl chloride. Additional carrier compositions include inorganic materials such as silicas, aluminosilicates, clays and the like.

Additional organic carrier compositions include: polyvinyl acetates or acetate chloride copolymer compositions, polyolefins, chlorinated polyethylenes, natural rubber, urea and melamine formaldehyde resins, polyesters, polyurethanes, polyureas, gelatins, straw, cane or lignocellulose materials and combinations of natural fibres with additional coatings of organic film-forming materials.

Controlled release techniques including micro-encapsulation and polymerisation(s) may be employed more accurately to control the release of the attractant or insecticide in the system's provided by this invention.

The invention will now be more fully described with reference to the following examples.

In the design of the insecticidal systems according to the present invention, there are two main objectives. The first is the protection of the active constituents of both the insect attractants and the insecticides and to cause their release at effective concentrations to take place over a cntrolled prolonged period. The second is to quantify the separate formulations of insect attractants and insecticide activity. This is desirable to avoid a situation arising in which the insecticide has been exhausted and the attractant retained, so causing a concentration, or attraction, of insects, without having available a suitable insecticide concentration. This example illustrates insecticidal systems according to the present

invention comprising a PVC-based carrier composition. An attractant carrier composition was prepared using:

	Parts by weight
Breon. P 130/1 (PVC Emulsion Polymer –BP Limited)	100.0
DOP (Dioctyl Phthalate–Plasticiser)	54.0
Vimco 249 C (Barium/Cadmium–Stabiliser)	2.5
ED6 (Epoxy Stabiliser–Lankro Chem. Co.)	5.0
Tinuvin P (UV Adsorber–Ciba-Geigy)	0.1
Pigment (Phthalocyanine Green or Chrome Yellow–according to attractant)	0.5
Insect Attractant	3.3

Approximately 15% of the plasticiser was charged into a mixer and the PVC polymer emulsion then added, followed by the remainder of the constituents in the order listed above. The balance of the plasticiser was then added, followed by the remainder of the constituents in the order listed above. The balance of the plasticiser was then added and mechanical mixing commenced, first at low speed and then at a higher speed, until a smooth paste was obtained which was passed through a triple-roll mill. The resultant paste was spread to a desired thickness (approximately 2 mm) onto a release paper and heated to 180 to 200°C for 3 minutes and then cooled for 10 minutes. This carrier composition contained approximately 2% by weight of the insect attractant.

Using a similar technique, an insecticide-containing carrier composition was prepared from the following formulation:

	Parts by weight
Vinmol E10/65P (PVC Emulsion Polymer)	100.0
B.Br. (Butyl Benzyl Phthalate Plasticiser)	60.0
Vinico 249 C (Barium/Cadmium Stabiliser)	2.5
ED6 (Epoxy Stabiliser–Lankro Chem. Co.)	5.0

	Parts by weight
Tinuvin P (UV Adsorber–Ciba-Geigy)	0.1
Pigment (Azo Red)	0.5
Insecticide	42.0

This yielded a carrier composition containing approximately 20% by weight of insecticide.

Example I

A carrier composition comprising, as an insect attractant, methyl eugenol, which is an attractant for the Oriental Fruit Fly, was prepared as described above. The carrier composition contained 2% by weight of the methyl eugenol.

A further carrier composition comprising insecticide was prepared, this time using, as insecticide, a mixture of equal parts by weight of:

Dichlorvos	2,2,dichlorvinyl-dimethyl phosphate
Naled, Dibrom	1,2-dibromo-2-2,dichloro ethyl dimethyl phosphate
Malathion	0,0-dimethyl S-diethyl-mercapto succinate phosphorodithioate

This insecticidal carrier composition contained 20% by weight of composition of the mixture of insecticides.

Test strips were prepared from the attractant and insecticide-containing carrier compositions, having the dimensions 10 cm × 5 cm × 0.2 cm. The airflow over the strips during the measurement of release rates was between 2 and 6 litres/hour. The temperature of the observations was in the range 20 to 25°C. These insecticidal systems had an effective life of 40 to 50 days and Table II below indicates the insect attractant and insecticide concentrations at Day 1 and in the Day 45/50 period.

TABLE II

	Milligrammes	
	Day 1	Day 45/50
Insect attractant	206	20
Insecticide	1570	908

Example II

The insect attractant was the Mediterranean Fruit Fly attractant, Capilure SGI (Food Industries Limited, Bromborough), at 2% on plastisol.

The insecticide used was Dichlorvos (20% by weight on plastisol).

The measurement of release of the insect attractant and insecticide showed the following conditions to be met over a life of 50 days. Table III indicates the concentration of the active components in the test strips at the stated times.

TABLE III

	Milligrammes		
	Day 1	Day 45	Day 50
Insect attractant	180	80	40
Insecticide	1630	210	180

Example III

2.0 mg (Z.E) 9,11 tetradecadien-1-yl acetate and 2.0 mg butylated hydroxy toluene were inserted into a low density polyethylene capsule 32 mm long and 16 mm diameter fitted with "snap" closure. A composition comprising Dichlorvos, Naled (Dibrom) and Malathion was prepared as described in Example I.

Measurement of the release of actives from these formulations under the standard conditions showed that the system had an effective lift of 25 to 30 days as set out in Table IV.

TABLE IV

	Milligrammes		
	Day 1	Day 25	Day 50
Insect attractant	2.0	0.13	0.02
	1570	950	930

Example IV

Controlled Release Insect Attractant (Lure) Composition Melon Fruit Fly (Dacus curcurbitae) Attractant—Cue Lure Constituents

Constituents	Composition % by weight
Polyvinyl chloride PVC Corvic D65/02	55.33
DIDP Plasticiser (Drisodecylphthalate)	29.57
Mark 33 (Calcium/zinc oxides) Stabilizer	1.38
Mark C Antioxidant (Trinonyl phenyl phosphite)	0.28
Paraplex G62 (Stabiliser/plasticiser) Epoxy Soya Bean Oil	2.77
Calcium Stearate (Lubricant)	0.18
Ultra-violet Adsorber Tinuvin P	0.06
Red Pigment (Vinamon G)	0.28
Insecticide (Mixture of equal parts of Dichlorvos, Dibrom and Malathion)	10.15
	100.00

Example V

Controlled Release—Lure Compositions

An alternative method of obtaining the desired controlled release rates of the lures and the insecticides, is illustrated:

The selected lure (Cue-lure, methyl eugenol or Trimedlure) was cold mixed into a matrix of an adhesive polymer composition based on acrylic polymer blends 50% and iso propyl acetate 50% (exemplified by Adhesive 5050 of Vinyl Products Limited, Carshalton, Surrey England). The intimately mixed adhesive and lure were spread onto 2 metre unit lengths of one of the following polymer films—each as a separate formulation.

Polythene
Polyvinyl chloride
Terephthalate polyester

These adhesive covered polymer films were then covered with a further polymer film of the same composition. These completed plastic sandwiches were approximately of dimensions 200 cm × 5 cm × 0.3 cm.

Adjuncts such as the antioxidants, ultra-violet screen compounds and dyes were included as required. *Lure contents* (Cue-lure, methyl eugenol or Trimedlure) per unit 2 metre length plastic sandwich strip were:

13.2 to 13.8 grammes

Controlled Release—Insecticide Compositions

In this example, a layer of insecticide, adhesive polymer mixture of composition:

	% by weight
Dichlorvos	37.5
Polymer (5050)	62.5

was spread evenly between two plastic strips (Polyester Terephthalate) Polymer/Insecticide layer was 5 cm wide.

Insecticide composition was:

Concentration	Per cubic centimetre	Per square centimetre	Per Centimetre length
Insecticide Dichlorvos	200.0 mg	8.0 mg	40.0 mg

	Compositions % by weight
Polyvinyl chloride PVC Corvic D65/02	60.15
DIDP Plasticiser (Di-isodecyl phthalate)	32.48
Mark 33 (Calcium/zinc oxides) Stabiliser	1.50
Mark C Antioxidant (Trinonyl phenyl phosphite)	0.30
Parapiex G62 (Stabiliser/plasticiser)	
Epoxy Soya Bean Oil	3.01
Calcium Stearate (lubricant)	0.18
Ultraviolet Absorber Tinuvin P	0.06
Green Pigment 21077 (Golden Valley Colours Limited)	0.31
Lure—Melon Fruit Fly Attractant (Cue-lure–4(p-acetoxyphenyl) butan-2-one)	2.01
	100.00

Mixing

The above formulation was mixed in a Papenmeir with adjustable rotor speeds.

Extrusion

The mixed blend was fed to a Betol single screw extruder to yield a plastic strip of 55 mm width and 2 mm thickness.

Extrusion Conditions

Barrel temperature—3 zones	150°C
Die temperature	155°C
Screw speed	30 revs/min
Die pressure	25 kg per sq cm
Output rate	400 mm/min

Concentration of Melon Fruit Fly Attractant (Cue-lure) in Plastic Strip—Exudates

Linear	=	24.5 mg per cm
Area	=	4.5 mg per sq cm
Volume	=	22.0 ,g per cubic cm

Release Rates of Lure (Cue-Lure)

The rates of release to surroundings of the Melon Fruit Fly attractant (Cue-lure) from the Controlled Release Polyvinyl chloride formulation described was measured according to method described by Martin Beroza, B.A. Bierl, Paul James and David de Vilbirs in Journal of Economic Entomology 1975, *63*, (No. 3), pages 369–372.

Measured release rates were within the range of 1500 to 50 nanogrammes of lure per hour at 22 to 25°C and 50 to 70% relative humidity.

The Insecticide Compositions
Controlled Release
Composition

The weight composition of the system is:

	Grammes	Percent
Total weight of a test strip	6.5	100.0
Weight of plastic film	3.0	46.2
Weight of adhesive polymer (5050)	2.2	33.8
Weight of insecticide	1.3	20.0

The properties of the film compositions used as illustrated by their vapour permeability properties for water vapour and oxygen.

	Thickness				Permeability Value	
Composition	ins	mm	Test Temp. °C	Test Relative Humidity %	Water Vapour gms/m²	Oxygen cc/m²
Polythene	0.001	0.025	25	—	1.0	350.0
PVC	—	0.013	25	75	2.0	192 × 106*
PVC	0.02	0.51	—	—	—	—
Terephthalate (Polyester)	0.001	0.025	38	90	0.90	19.0

*Test carried out at 21°C and 44% relative humidity.

In the accompanying drawings:
Graphs I and IA show the release of the active components of Example I.
Graph 2 gives similar information in relation to Example II.

CLAIMS

1. An insect control system comprising an assembly of at least one insecticidal carrier composition and one insect attractant carrier composition, said compositions being formulated to provide effective lives for the compositions of substantially the same period.
2. An insect control system as claimed in Claim 1 in which the effective life of the insecticidal composition is longer than that of the attractant composition.
3. An insect control system as claimed in Claim 1 or 2, in which the assembly of compositions is juxtaposed.
4. An insect control system as claimed in Claim 3 in which the juxtaposed compositions are in the form of interwined tapes or strings.
5. An insect control system as claimed in Claim 3 in which one carrier composition comprises a polymeric sheet material incorporating the insecticide and carrying, on at least one surface, a secondary carrier composition containing the insect attractant, the secondary composition being in the form of discreet particles.
6. An insect control system as claimed in Claim 5 in which the discreet particles formed from the secondary carrier composition and the insert attractant are in the range of diameters up to half the length of the insect under attack.
7. An insect control system as claimed in Claim 3 in which one of the compositions is in micro-encapsulated form and carried on the surface of the other composition.
8. An insect control system as claimed in any one of the preceding claims in which the assembly is located in an insect trap.
9. An insect control system, substantially as described herein, with reference to the Examples.

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